# Geospatial Intelligence (GEOINT) - Automation, Artificial Intelligence and Augmentation (AAA)

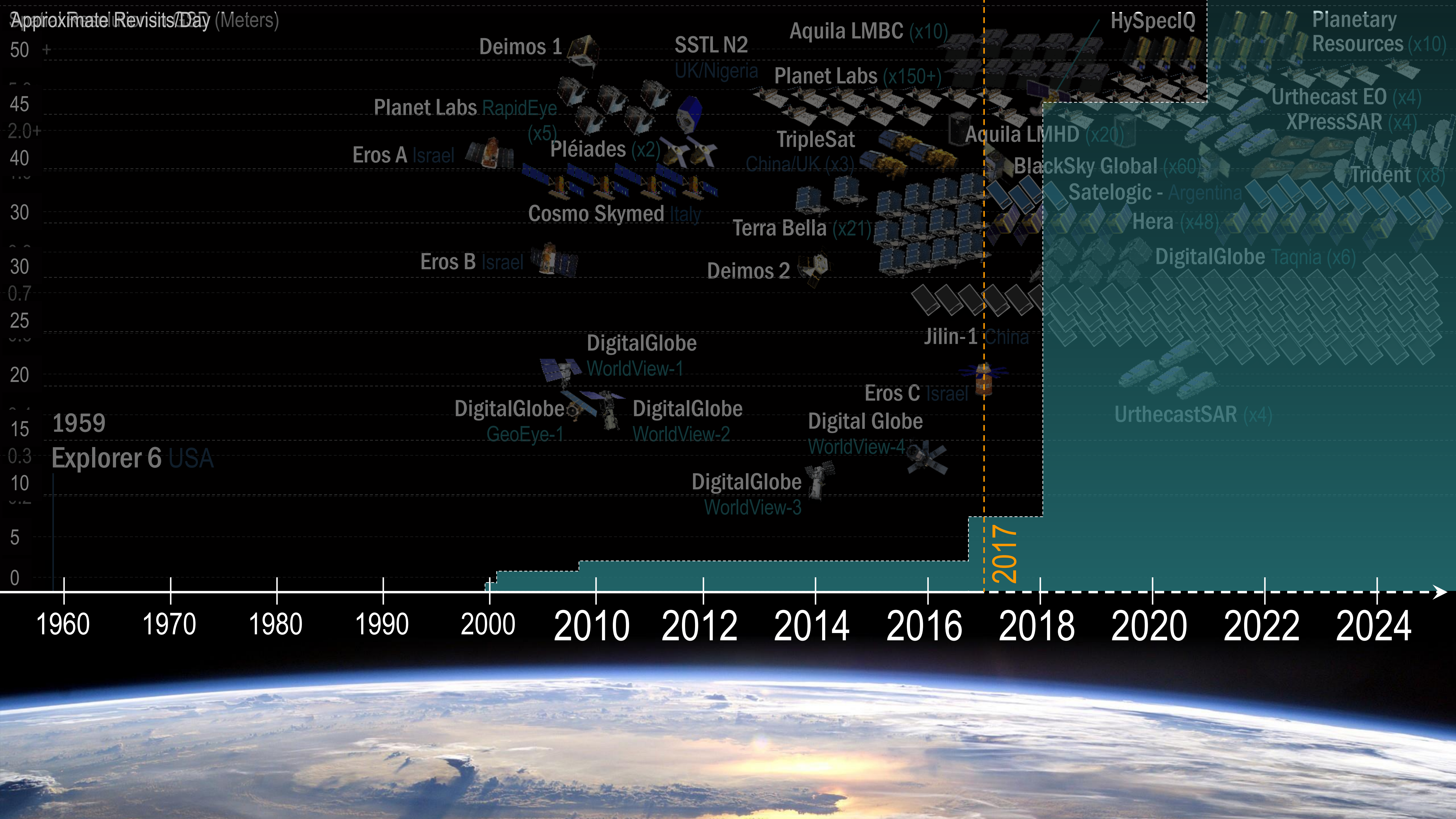
William “Buzz” Roberts

27 November 2018

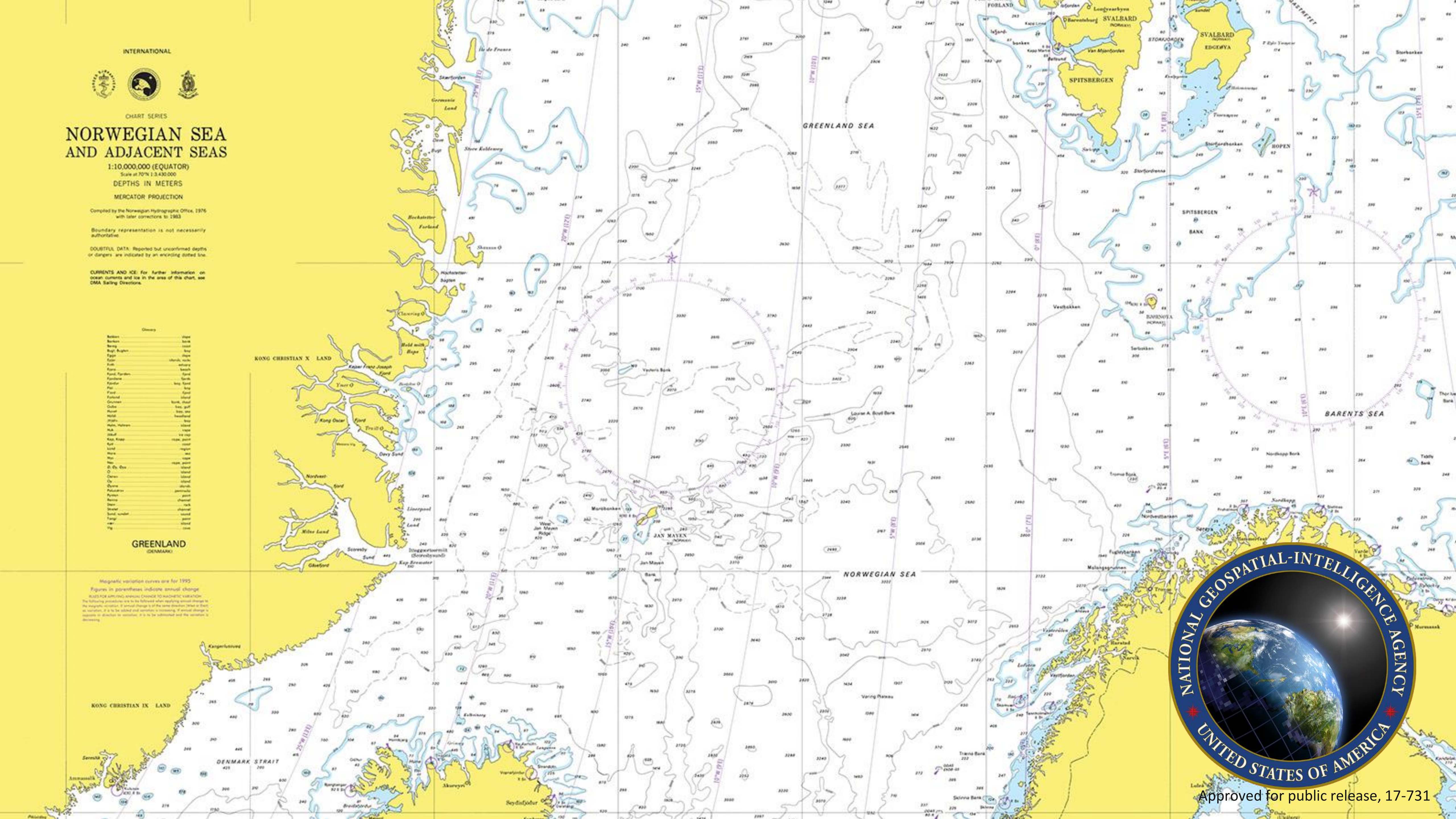


Approved for public release, 19-155


GEOINT DATA:
INFRARED
RADAR
LIDAR
PANCHROMATIC
MULTISPECTRAL
OPEN SOURCE
HUMAN GEOGRAPHY
LAND
SEA
AIR
SPACE
Approved for public release, 17-731



Approximate Revisits/Day (Meters)
50
45
2.0+
40
30
30
0.7
25
20
15
0.3
10
5
0
1959
Explorer 6 USA
Deimos 1
SSTL N2
UK/Nigeria
Aquila LMBC (x10)
Planet Labs (x150+)
HySpecIQ
Planetary Resources (x10)
Planet Labs RapidEye (x5)
Eros A Israel
Pléiades (x2)
TripleSat China/UK (x3)
Aquila LMHD (x20)
Urthecast EO (x4)
XPressSAR (x4)
BlackSky Global (x60)
Trident (x8)
Satelogic - Argentina
Cosmo Skymed Italy
Terra Bella (x21)
Hera (x48)
DigitalGlobe Taqnia (x6)
Eros B Israel
Deimos 2
Jilin-1 China
DigitalGlobe WorldView-1
Eros C Israel
DigitalGlobe GeoEye-1
DigitalGlobe WorldView-2
Digital Globe WorldView-4
UrthecastSAR (x4)
DigitalGlobe WorldView-3
2017
1960
1970
1980
1990
2000
2010
2012
2014
2016
2018
2020
2022
2024




Approved for public release, 17-731

# NGA Capabilities . . .

**INTELLIGENCE**

- Strategic Intelligence
- Indications and Warning

- Foundation Data
- Special Event Planning
- Safety of Navigation

**DEFENSE**

- Warfighter Support

**CIVILIAN**

- Homeland Defense
- Humanitarian and Disaster Relief

# . . . Enable Decision Advantage

# NGA By The Numbers

LAND | SEA | AIR | SCIENCE | HUMAN GEOGRAPHY

## LAND

**196 MILLION**
**SQUARE KILOMETERS OF PRECISE STEREO AND MONO-ORTHORECTIFIED IMAGERY**

1.2 Billion Features

204,000 Standard Maps

## SEA

**70 MILLION**
**HYDROGRAPHIC FEATURES**

5,000 Nautical Charts

3,900 Digital Nautical Charts Libraries

24/7 Worldwide Navigation Warning Service

79 Nautical Publications

Notice to Mariners

## AIR

**4 BILLION**
**AERONAUTICAL DATA ELEMENTS**

48,000 Airfields in Automated Air Facilities Intelligence File

32 Million Vertical Obstructions

22,000 Instrument Flight Procedures in Digital Aeronautical Flight Information File

3,000 DOD Flights per Day

## SCIENCE

**125 MILLION**
**GRAVITY RECORDS**

World Geodetic System 1984 Reference Frame

270 Million Square Kilometers of Elevation Data Coverage

Foundation for all DOD and Positioning, Navigation, and Timing

## HUMAN GEOGRAPHY

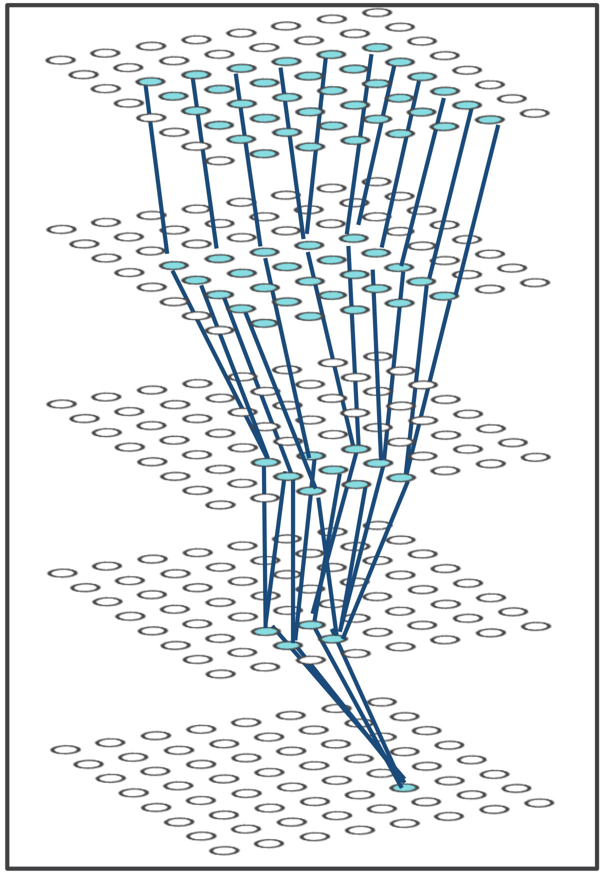
**11 MILLION**
**GEOGRAPHIC NAMES**

15,000 Human-Geography-Related Feature Classes

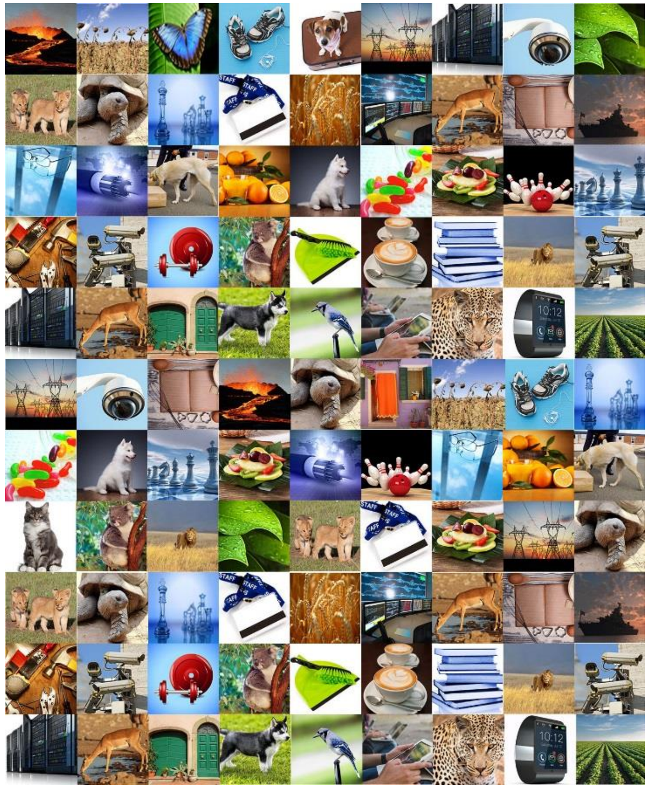
50,000 Maritime and Land Boundaries

# Deep Learning – A Powerful New Hammer

Theory



Massive labeled data

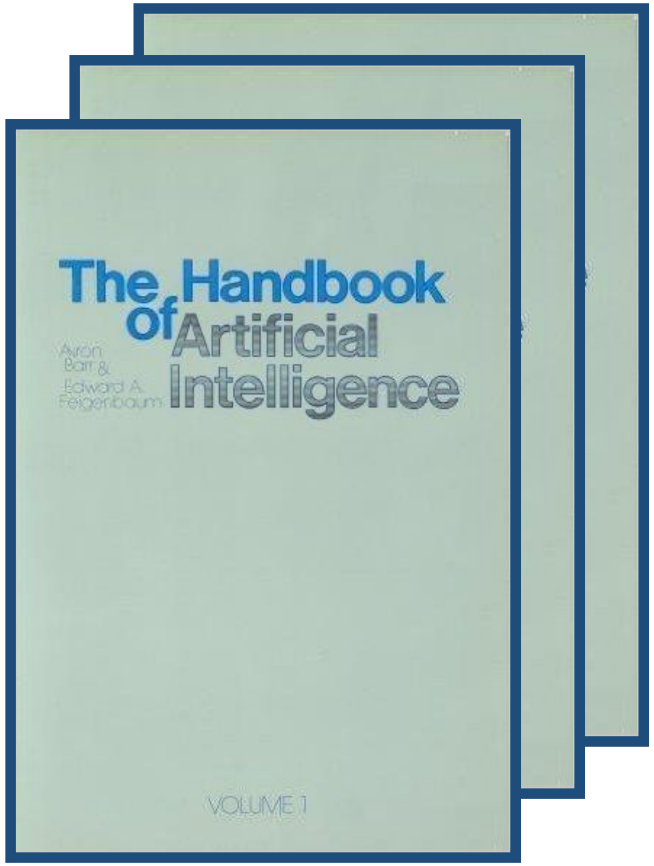


Photos– iStock.com

Cheap powerful computers

# Artificial Intelligence / Machine Learning

- Long, mostly academic, history
- Limited, but profound, successes
- Narrow AI (i.e., ML) has shown value
- Much GEOINT well-suited for ML
- ML performance not well understood
- USG R&D continues to play key role




Three volumes, originally
Published in 1985

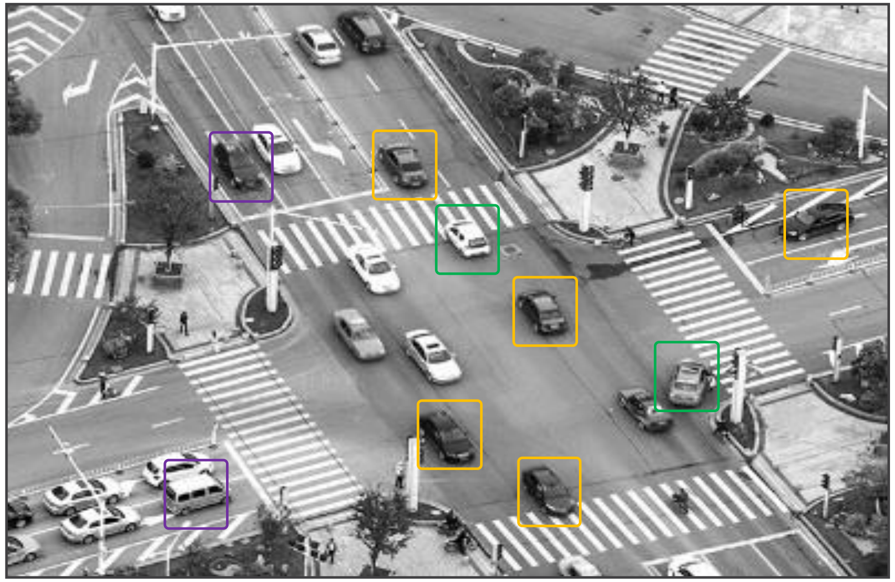
NGA



Approved for public release, 17-173

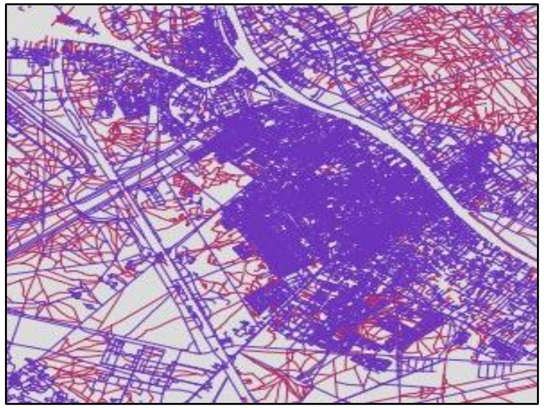
# GEOINT Application Examples

- Exploit scene knowledge
- Automate mundane enable analysis
- Support D&D defeat
- Handle massive, multimodal data

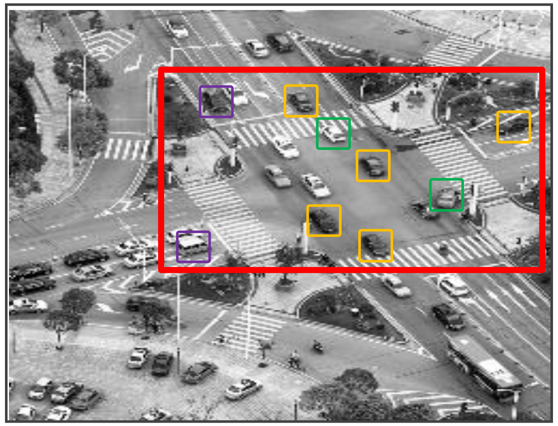


https://en.wikipedia.org/wiki/Military_dummy
This is a file from the Wikimedia Commons

https://en.wikipedia.org/wiki/Military_dummy
This is a file from the Wikimedia Commons



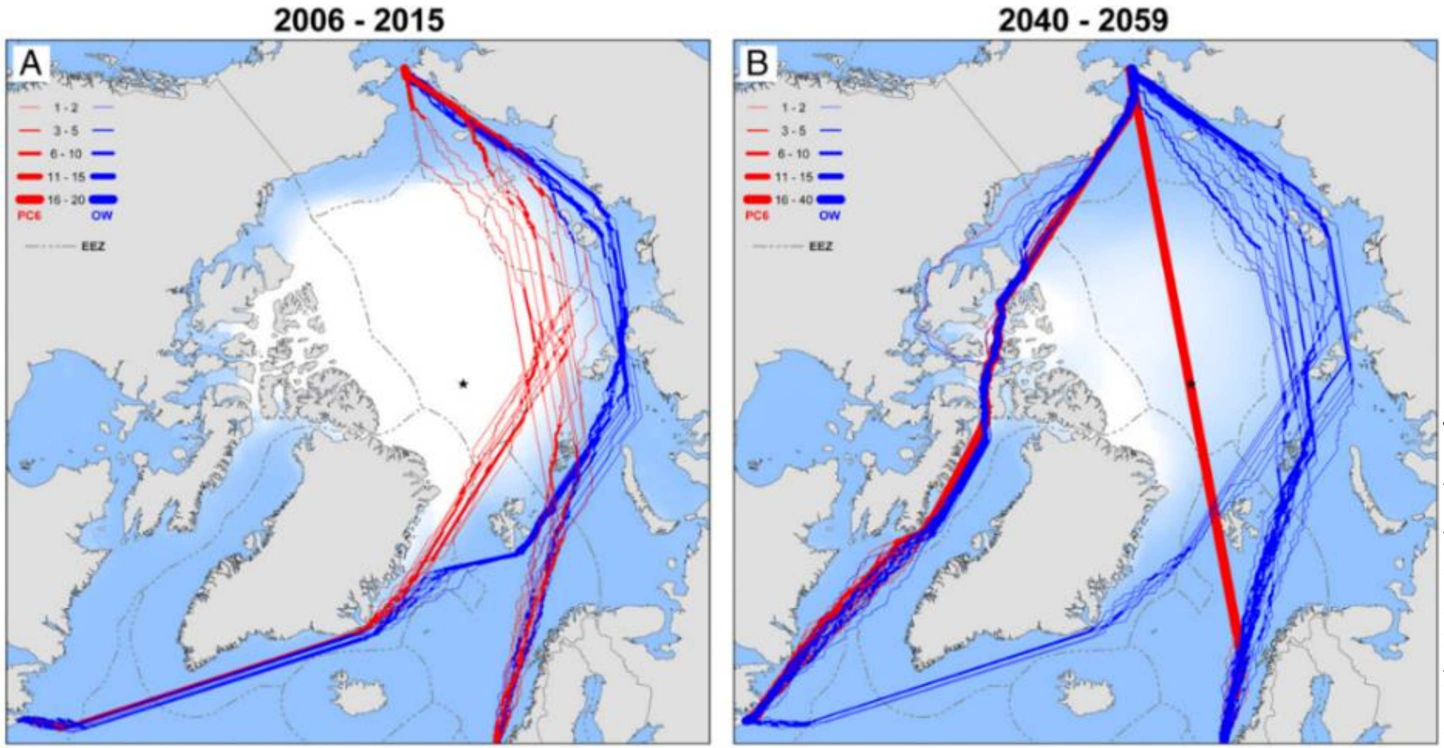
Source: Vector Data Sources: OpenStreetMap (OSM) public data; NGA Feature Foundation Data (FFD), Approved for Public Release, 15-373



Sydney, Australia– iStock.com

NGA

# Arctic Travel Routes

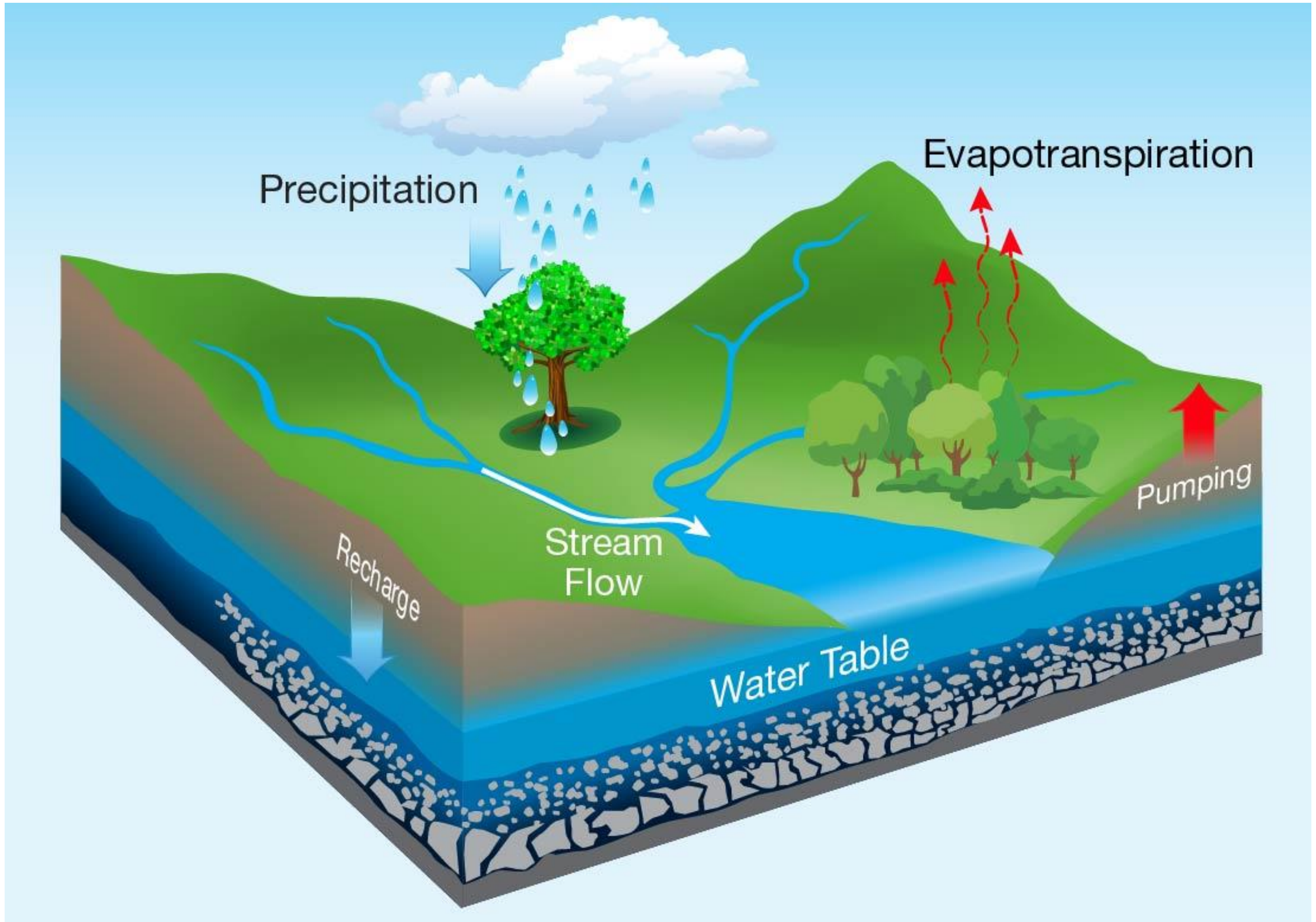





**Red**: transit routes for medium icebreaker
**Blue**: transit routes for open water vessel

**Develop a weather-related risk assessment analytic for arctic routes**

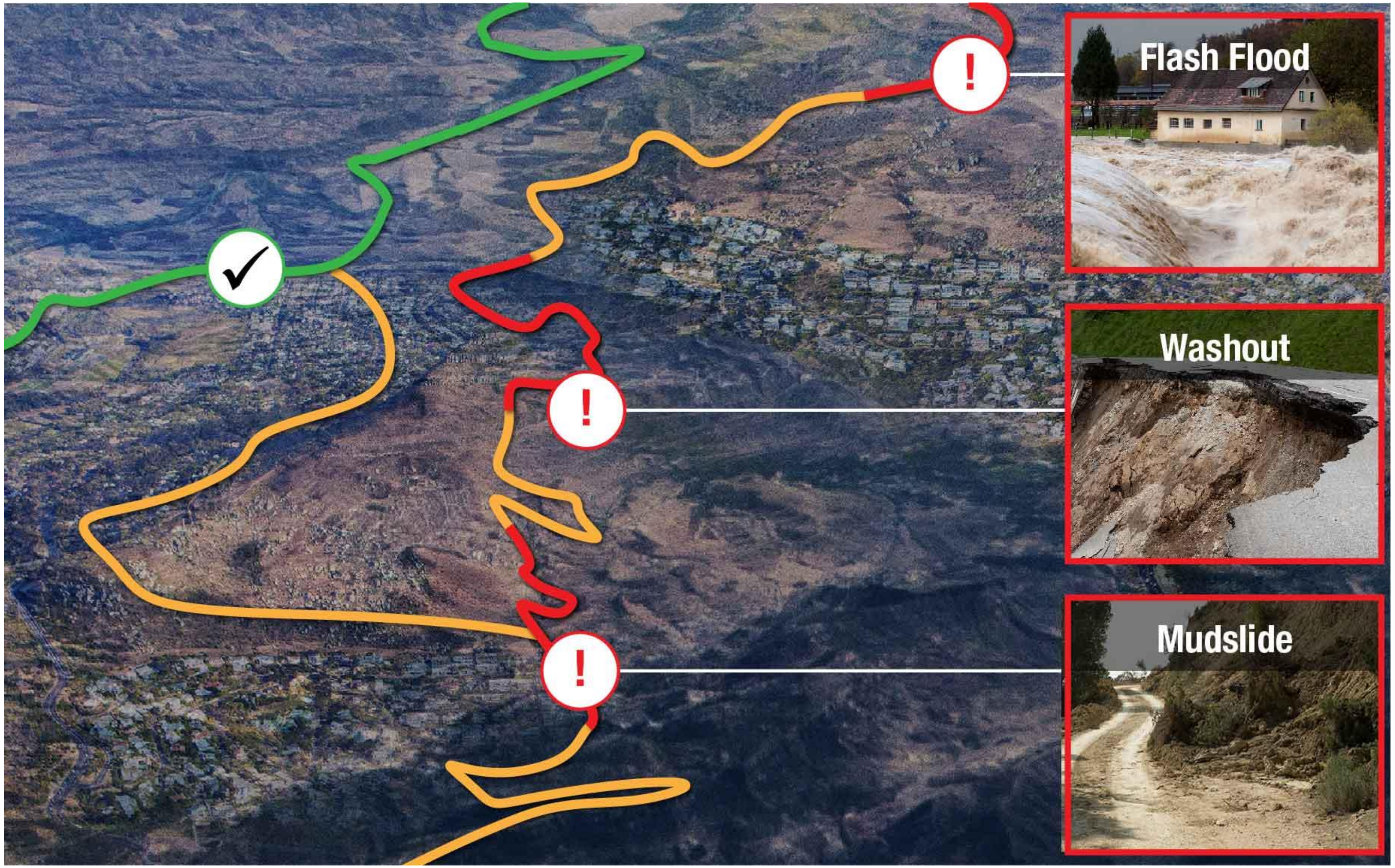
# Water Budget Prediction



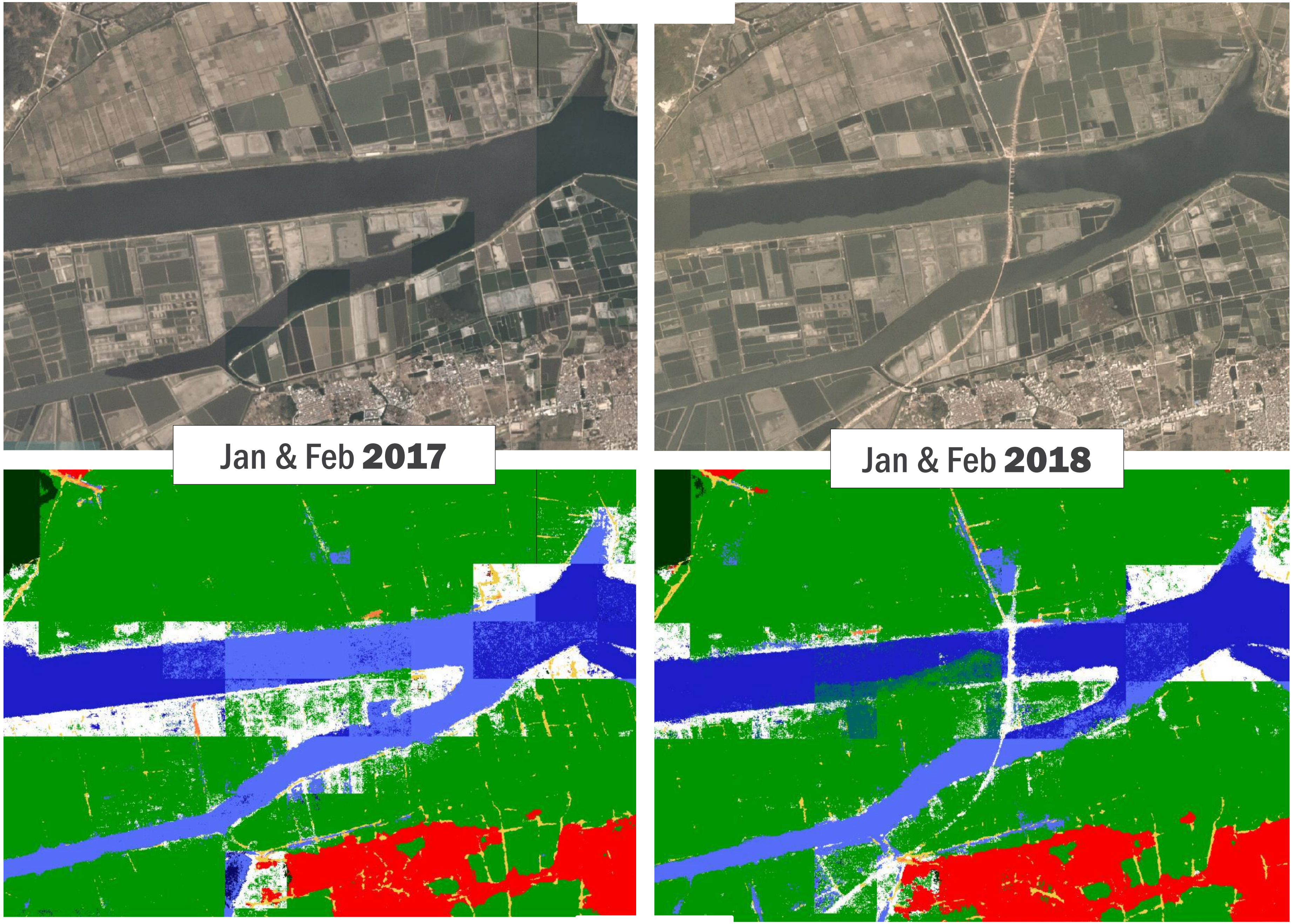



Approved for public release, 18-942

# Mission Routes




Develop a weather-related risk assessment analytic for routes


Jan & Feb 2017
Jan & Feb 2018

# Machine Learning: The High-Interest Credit Card of Technical Debt

**D. Sculley, Gary Holt, Daniel Golovin, Eugene Davydov,**
**Todd Phillips, Dietmar Ebner, Vinay Chaudhary, Michael Young**
{dsculley,gholt,dgg,edavydov}@google.com
{toddphillips,ebner,vchaudhary,mwyoung}@google.com
Google, Inc

## Abstract

Machine learning offers a fantastically powerful toolkit for building complex systems quickly. This paper argues that it is dangerous to think of these quick wins as coming for free. Using the framework of *technical debt*, we note that it is remarkably easy to incur massive ongoing maintenance costs at the system level when applying machine learning. The goal of this paper is to highlight several machine learning specific risk factors and design patterns to be avoided or refactored where possible. These include boundary erosion, entanglement, hidden feedback loops, undeclared consumers, data dependencies, changes in the external world, and a variety of system-level anti-patterns.

*Date of publication: 2014*

# Issues

- AI/ML technology & expertise available worldwide
  - ▶ Relentless focus on differentiation
- Novel software not robust
  - ▶ Security must be a priority
- Limited training data
  - ▶ Partnerships (e.g., SpaceNet, xView), transfer learning
- ML success & failure modes not well understood
  - ▶ Theory and experimentation essential

Figure from **Explaining and Harnessing Adversarial Examples**
Ian J. Goodfellow, Jonathon Shlens, Christian Szegedy published as a conference paper at ICLR 2015
https://arxiv.org/pdf/1412.6572.pdf

# Opportunities

- GEOINT automation is required
  - ► ML good match for automating fundamental extraction
- Massive training data are required
  - ► NGA is uniquely situated to help provide
- Significant expertise and innovation required
  - ► Industry, academia and federal R&D aggressively investing

# Challenge


Find all images over a large region that meet the following criteria:

- Agricultural activity
- All modalities

Identify and create vectors agricultural regions across modalities

Present vectors with reduced of the agricultural utilization or crop damage

**Automated cross modal image segmentation and object extraction**

Look for trends in "at risk" regions over previous 5 years of imagery across all modalities

Predictive analytics on related socio-economic data

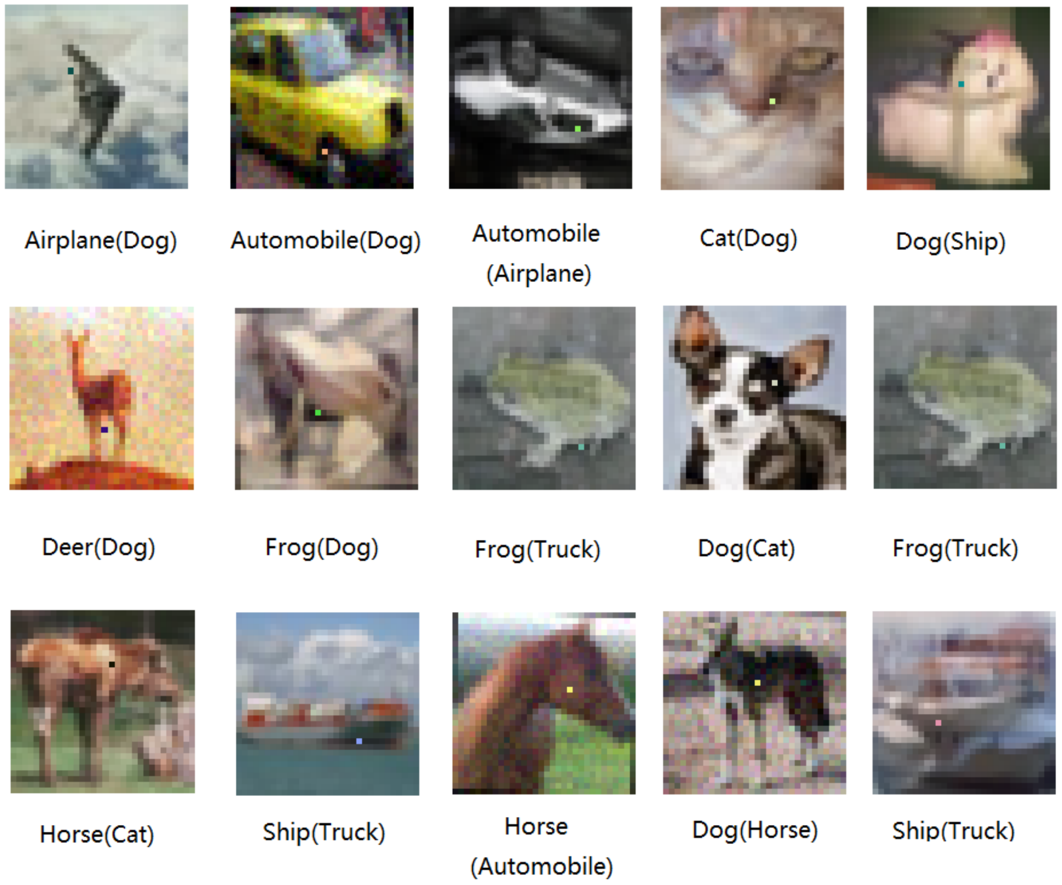
**Multi-int evolving and emerging pattern identification**

# Cross-modality target signature prediction


- Using target observations in one modality, predict material properties and response in other modalities
- Rapidly generated prediction is key to generating volumes of data needed for Machine Learning training and for predictions to serve as a manual analysis aid

# Most Recent Examples of Adversarial Attacks on Deep Learning

One-Pixel Attacks
(24 October 2017, Kyushu University, Japan)




74% of images misclassified with 98% confidence
Black-box attack

Real 3D Objects (30 October 2017, MIT)




Approved for public release, 19-155

# Adversarial Patch

Brown, Mane, Roy, Abadi, Gilmer
NIPS 2017

# It's All About The Data

# NGA Research

A trusted partner and source of powerful new capabilities

- Automate
- Enrich
- Assure
- Compute
- Transition

## Ensuring The Unfair Fight

NGA
NATIONAL GEOSPATIAL-INTELLIGENCE AGENCY

NGA.mil